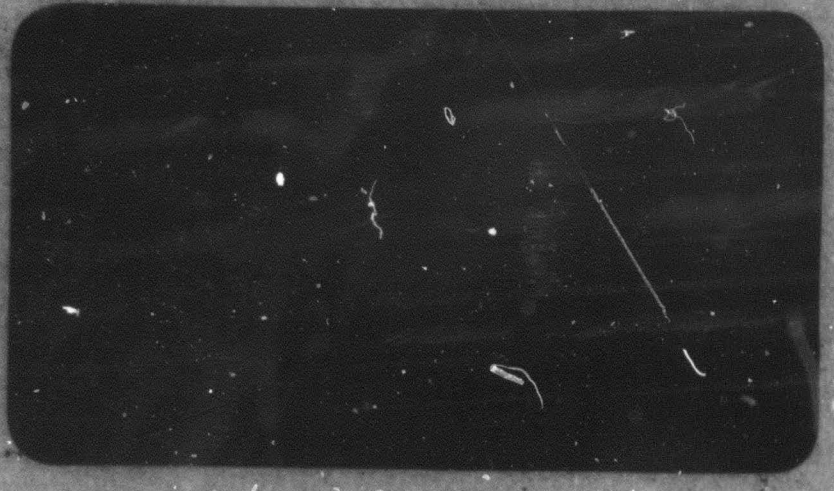


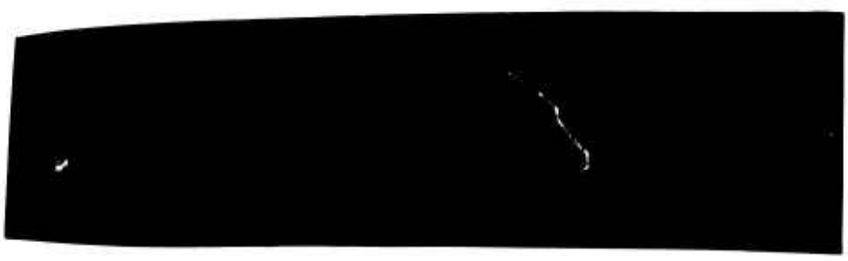
# SOVIET ASTRONAUTICS

by

F. J. Krieger

P-1437

February 24, 1958





The views expressed in this paper are not necessarily those of the Corporation

LECTURES FROM "AN INTRODUCTION TO ASTRONAUTICS" PUBLISHED AS RAND PAPERS

| Lecture | Title and Author | Paper |
|---|---|---|
| 2 | The Space Environment, by A. G. Wilson | P-1427 |
| 3 | Trajectory Fundamentals, by S. Herrick | P-1303 |
| 4 | Types of Flights, by R. W. Buchheim | P-1428 |
| 5 | Propulsion Fundamentals, by B. Pinkel | P-1429 |
| 7 | Materials for Space Flight, by G. A. Hoffman | P-1420 |
| 9* | Aerodynamics for Space Flight, by E. P. Williams and C. Gazley, Jr. | P-1256 |
| 10 | The Penetration of Planetary Atmospheres, by | P-1322 |
| 13 | Orientation and Control, by T. B. Garber | P-1430 |
| 14 | Some Information Theory Considerations in Space Communications, by P. Swerling | P-1393 |
| 15 | Communication in Space Operations, by C. M. Crain and R. T. Gabler | P-1394 |
| 16 | Internal Environment of Manned Space Vehicles, by S. H. Dole | P-1309 |
| 17* | A Discussion of Energy Sources for Space Communications, by J. H. Huth | P-1318 |
| 19 | Space Flight Ground Facility Requirements Problems--Launching Facilities, by J. J. L'Sullivan | P-1431 |
| 20 | Scientific Exploration in the Fringe of Space, by W. W. Kellogg | P-1350 |
| 21 | Physics of Solar-Terrestrial Space: Lunar Flight, by E. H. Vestine | P-1344 |
| 22 | Interplanetary Exploration, by A. G. Wilson | P-1432 |
| 23 | Some Elementary Facts of Relativity, by H. A. Lang | P-1433 |
| 24 | Outer Space and International Law, by Leon Lipson | P-1434 |
| 25 | Some Political Implications of the Space Age, by J. M. Goldsen and Leon Lipson | P-1435 |

*The paper is based on unclassified portions of the lecture.

# SOVIET ASTRONAUTICS

by

F. J. Krieger

THE PAPER?

This lecture describes the ~~long and active~~ history of Soviet interest in space flight leading up to the launching of Sputniks I and II. A discussion of Soviet technical and popular literature on space flight is included.

## SOVIET INTEREST IN SPACE FLIGHT

Russia has a rich historical background in astronautics that began at the end of the nineteenth century with the works of I. V. Meshcherskii on the dynamics of bodies of variable mass and the publications of K. E. Tsiolkovskii on principles of rocket flight. Early Russian rocket enthusiasts made many fundamental contributions to this new technology.

Tsiolkovskii, the father of (and to the Soviets, the patron saint of) the science of astronautics, has been fairly well represented by rocket historians in Western literature. Not so, however, his contemporaries--F. A. Tsander, who developed the idea of utilizing as fuel the metallic structural rocket-ship components which were no longer necessary and who in 1932 built and successfully tested a rocket motor operating on kerosene and liquid oxygen; Yu. V. Kondratyuk, who proposed the use of ozone as an oxidant and developed the idea of aerodynamically braking a rocket returning from a voyage in space; N. A. Rynin, who during the period 1928-1932 published a monumental 9-volume treatise on astronautics; Ya. I. Perel'man, the great popularizer of astronautics; and I. P. Fortikov, the organizer.

In 1929 Perel'man, Fortikov, and other disciples of Tsiolkovskii

founded a competent scientific organization for investigating and systematically developing new rocket devices, called GIRD, after the initials of the Russian words for "Group for the Study of Reactive Motion." The Moscow branch, founded by Tsiolkovsky, was known as Mosgird; the Leningrad branch, founded by N. A. Rynin and Ya. I. Perel'man, as Lengird. GIRD was essentially a part of a larger organization known as OSOAVIAKHIM (Society for the Promotion of Defense and Aero-Chemical Development). The papers written by various members of this organization contain a wealth of evidence of native competence in the various aspects of rocketry and space flight and clearly indicate that the Russians possessed a relatively high degree of technical sophistication more than two decades ago.[1]

The GIRD publications included contributions by I. A. Merkulov, Yu. A. Pobedonostsev, and M. K. Tikhonravov, who are still very active in the field of rocket propulsion and space flight.

Quick to realize the enormous military potential of the rocket, the Soviet Government had organized, by 1934, a Government-sponsored rocket-research program--only five years after Germany had embarked on its rocket program but eight years before similar systematic Army-sponsored research began in the United States. Stalin's personal interest in the development of long-range, rocket-propelled guided missiles is discussed in the book Stalin Means War by Colonel G. A. Tokaev, formerly chief of the aerodynamics laboratory of the Moscow Military Air Academy, who defected from the Soviet zone of Germany to Great Britain in 1948.

---

[1] E.g., Proceedings of the All-Union Conference on the Study of the Stratosphere, March 31-April 6, 1934, USSR Academy of Sciences, 1935, and collections of papers titled Rocket Technology and Jet Propulsion, Union of Scientific Technical Publishing Houses, 1935, 1936. Unfortunately, few, if any, of the latter items reached the United States, -- perhaps for obvious reasons!

The Soviets have pursued an aggressive rocket policy since 1945. In addition to appropriating most of the German rocket factories and test stations, they have induced several hundred German rocket experts to work for them behind the Iron Curtain. The Russians have built a large number (probably several thousands) of German V-2 missiles, presumably for fundamental rocket and upper-atmosphere research, for gaining experience in mass-producing large rocket missiles, and for training rocket-launching crews. They have not only improved on the V-2 rocket engine--increasing its thrust from 25 to 35 metric tons by increasing the propellant flow rate[2]--but have also developed a super-rocket (Model 103) with a fantastic thrust of 120 metric tons at a chamber pressure of 60 atmospheres. These developments indicate that the Russian effort has been more than an extension of previous German work; to all indications it is based on independent thinking and research. This is not surprising, since Russia has its share of exceptionally capable technical men such as Semenov (the recent Nobel Prize winner in chemistry) and Zel'dovich, Khristianovich and Sedov--to mention but a few in the fields of combustion theory and fluid dynamics.

Because of high security restrictions, very little factual information on Russian missile developments has ever been released. However, in his address to the World Peace Council in Vienna on November 27, 1953, Academician A. N. Nesmeyanov, speaking on the problems of international cooperation among scientists, made the following significant statement: "Science has reached a state when it is feasible to send a stratoplane to the moon, to create an

---

[2] This is essentially what Rocketdyne, a division of North American Aviation, did in this country in developing the Redstone 75,000-pound thrust rocket engine.

artificial satellite of the earth...."[3] This statement is particularly interesting in view of the events that have transpired since it was made. In his official capacity as president of the USSR Academy of Sciences, Nesmeyanov was, of course, familiar with all aspects of Soviet scientific progress; his statement clearly implied that Russian progress in rocket propulsion as of 1953 had made feasible such feats as launching an earth satellite and flying to the moon.

To all indications, Nesmeyanov's statement as to the feasibility of sending a stratoplane to the moon and of creating an artificial earth satellite became the keynote for a flood of articles on the problems of space flight that began to appear early in 1954 in almost every type of Russian newspaper and periodical.

There is considerable evidence of early acceptance of the science of space flight by the Soviet hierarchy. It is not without significance that Volume 27 of Bol'shaya Sovetskaya Entsiklopediya (Large Soviet Encyclopedia), published in June, 1954, contained an article entitled "Interplanetary Communications" by M. K. Tikhonravov.[4] There is as yet no corresponding entry in any of the Western encyclopedias. Interestingly, the New York Times began to index articles on space ships and space flight under the term "Astronautics" only after the White House announced on July 29, 1955, that the United States intended to launch an earth satellite.

Soviet interest in space flight was further revealed by the fact that on September 24, 1954, the Presidium of the USSR Academy of Sciences established the K. E. Tsiolkovskii Gold Medal for outstanding work in the

---

[3] Pravda, November 28, 1953.

[4] In Russian the term "interplanetary communications" is synonymous with "astronautics" and "space flight."

field of interplanetary communications, to be awarded every three years beginning with 1957. At about the same time, the Presidium established the permanent Interdepartmental Commission on Interplanetary Communications to "coordinate and direct all work concerned with solving the problem of mastering cosmic space." Academician L. I. Sedov, a topnotch hydrodynamicist, was appointed chairman, and M. K. Tikhonravov--who designed and successfully launched liquid-propellant atmospheric research rockets in 1934--was appointed vice chairman.

In addition to the ICIC, an Astronautics Section was organized early in 1954 in Moscow at the V. P. Chkalov Central Aeroclub of the USSR. Its goal was "to facilitate the realization of cosmic flights for peaceful purposes." Its charter members included Chairman N. A. Varvarov, Professor V. V. Dobronravov, Design Engineer I. A. Merkulov, Stalin Prize Laureate A. D. Seryapin, Professor K. P. Stanyukovich, Yu. S. Khlebtsevich, and International Astronautics Prize Winner, A. A. Shternfel'd.

Although the White House announcement of July 29, 1955 -- that the United States intended to launch an earth satellite sometime during the International Geophysical Year (1957-1958) -- led to considerable speculation concerning the Soviet position and capability in this field of technology, the imperturbable Russians, as usual, did not commit themselves. Possibly they were only too well aware of the United States Earth Satellite Vehicle Program, the existence of which was first publicly announced by Secretary of Defense Forrestal in December, 1948.

A notable event occurred in the week following the White House announcement. The Sixth International Astronautical Congress sponsored by the International Astronautical Federation convened in Copenhagen,

Denmark. It was notable because, unlike previous meetings, it was attended by two Soviet scientists, Academician L. I. Sedov, Chairman of the USSR Academy of Sciences Interdepartmental Commission on Interplanetary Communications, and Professor K. F. Ogorodnikov, a professor of astronomy at Leningrad State University, who was an exchange professor at Harvard in 1937.

The Russians were observers at the Congress and did not participate in any formal discussion of the papers. Sedov, however, did hold a press conference on August 2 at the Soviet Legation in Copenhagen, but unfortunately some of the statements attributed to him were garbled in the Western press. Three days later, on August 5, Pravda published an official version of the press conference in which Sedov indicated that "recently in the USSR much consideration has been given to research problems connected with the realization of interplanetary communications, particularly the problems of creating an artificial earth satellite.... In my opinion, it will be possible to launch an artificial earth satellite within the next two years, and there is a technological possibility of creating artificial satellites of various sizes and weights. From a technical point of view, it is possible to create a satellite of larger dimensions than that reported in the newspapers which we had the opportunity of scanning today. The realization of the Soviet project can be expected in the comparatively near future. I won't take it upon myself to name the date more precisely." It is interesting to compare this obviously edited official Soviet version of the press conference with the unedited version published in the Western press two days earlier. Later, after his return to Moscow, Sedov's impressions of the Astronautical Congress appeared in the Soviet press

Six months later, in February, 1956, the Russians held a conference at Leningrad State University to discuss problems of the physics of the moon and the planets. More than fifty scientists participated. The two principal topics for discussion were (1) the questions of planetology connected with the problems of astronautics and, primarily, the question of the state of the moon's surface, and (2) the exchange of opinions and plans for observations of the coming great opposition of Mars in September, 1956. Professor N. P. Barabashev, conference chairman and director of the Khar'kov University Observatory, pointed out that the importance of planetology was growing substantially in connection with the demands of cosmonautics and that, at the same time, the responsibility of planetary, and especially lunar, investigators was increasing. M. K. Tikhonravov, vice chairman of the Commission on Interplanetary Communications, enumerated the basic questions to which astronauts expect answers from the science of planetology.

At the Conference on Rockets and Satellites, held on September 11, 1956, during the fourth general meeting of the Comité Spécial de l'Année Geophysique Internationale (CSAGI) in Barcelona, Spain, there occurred a prime example of official Soviet reticence to make factual pronouncements concerning rocketry and space flight. In presenting the general description of the Soviet Union's rocket and satellite program to an audience that was eagerly awaiting the Russian announcement, Academician I. P. Bardin, chairman of the USSR IGY National Committee and a vice president of the USSR Academy of Sciences, read the following statement in Russian:[5]

---

[5] Dr. V. A. Troitskaya, scientific secretary of the Soviet National Committee, read the accompanying English version immediately after Bardin's original statement.

"At the request of the General Secretary of the CSAGI, Dr. M. Nicolet, inquiring as to the possibility of the Soviet Union's participation in the Rocket-Satellite program, the Soviet National Committee announces that:

"(1) In addition to the USSR program already presented to the Barcelona meeting the Rocket-Satellite program will be presented at a later time.

"(2) The USSR intends to launch a satellite by means of which measurements of atmospheric pressure and temperature, as well as observations of cosmic rays, micro-meteorites, the geomagnetic field and solar radiation will be conducted. The preparations for launching the satellite are presently being made.

"(3) Meteorological observations at high altitudes will be conducted by means of rockets.

"(4) Since the question of USSR participation in the IGY Rocket-Satellite observations was decided quite recently the detailed program of these investigations is not yet elaborated.

"This program will be presented as soon as possible to the General Secretary of the CSAGI."

Needless to say, this unexpected and vapid statement left the assembled throng with a sense of complete frustration. No mention of it appeared in the Soviet press for more than two weeks. Finally, on September 26, a TASS report, captioned "Preparation for the International Geophysical Year" and bearing no dateline, appeared on page 4 of Krasnaya Zvezda (Red Star). The report quoted Academician Pardin as saying that "The Soviet delegation's statement that work is being conducted in the USSR, just as in the USA, on preparations for upper atmosphere research by means of rockets and artificial satellites evoked great interest among the participants of the session. These satellites will revolve around the Earth, making a complete revolution in less than one hour and a half. They will be relatively small, approximately the size of a [soccer] football. They will weigh about nine kilograms. Now scientists are making more precise a number of

conditions for successfully launching the satellites...."

The Bardin item is in keeping with the generalized nature of Soviet reports and articles concerning their satellite plans and specifications. Stereotyped statements and reports are apparently a matter of policy. This was admirably summarized by an American IGY scientist, who (according to an Associated Press dispatch datelined Washington, October 2, 1957) said that Russian delegates had told him repeatedly that they consider it "bad taste to make announcements in advance. Our policy is not to release any details until we have experimental results."

By 1956 the USSR Academy of Sciences felt the need to apply for membership in the International Astronautical Federation. The application was voted on favorably during the Seventh International Astronautical Congress in Rome in September of that year. Moreover, the Soviet Union's lone observer-delegate to that Congress--L. I. Sedov--was elected a vice president of the Federation.

More than a year passed, however, before the Soviet Union complied with the by-laws of the International Astronautical Federation and submitted, through Sedov, a description (that is, an equivalent of a constitution) of the Academy's Interdepartmental Commission on Interplanetary Communications and a list of its members.

The main purpose of the Commission, it seems, is to assist in every way possible the development of Soviet scientific-theoretical and practical work concerning the study of cosmic space and the achievement of space flight. Its specific duties and functions are manifold and involve the initiation, organization, coordination, and popularization of the problems of space flight, as well as the propagandization of the successes achieved.

The list of twenty-seven members of the Commission is a very impressive one. It includes eight academicians, some of Russia's--and the world's--top scientists. There is no question of the stature in world science of such men as P. L. Kapitsa, the famed physicist, N. N. Bogolyubov, the mathematical genius who is said to be the Russian counterpart of the late John von Neumann, V. A. Ambartsumyan, the noted Armenian astrophysicist, and others. Although most of the members of the Commission are pedagogues, that is, connected with some institute of higher learning, a number of them wear several hats, including military hats. Academician A. A. Blagonravov, for example, is a Lieutenant General of Artillery and is a specialist in automatic weapons. G. I. Pokrovskii is a Major General of Technical Services and an explosives expert. V. F. Bolkhovitinov holds the rank of Major General and is a professor of aeronautical engineering at the Military Air Academy. Yu. A. Pobedonostsev is a Colonel, a professor of aerodynamics at Moscow State University and a specialist in gas dynamics. It is quite evident that the military is well represented in the Interdepartmental Commission on Interplanetary Communications.

Because of the Soviets' extreme reluctance to reveal their activities in the field of astronautics, the myriad articles on the problems of space flight that appeared in the popular press prior to the end of 1956 presented, for the most part, well-known information from the Western press with only occasional broad hints as to developments in the Soviet Union. Soviet technical journals, however, continued--as they had in the past--to present articles of considerable interest and merit, especially in the fields of flight mechanics and hydrodynamics.

Soviet [illegible] delegation

of thirteen scientists, headed by Academician A. A. Blagonravov, an armaments specialist and a member of the Presidium of the Academy of Sciences, attended the First International Congress on Rockets and Guided Missiles in Paris. There the Russians presented two papers which revealed the prodigality of their rocket-test program: In the Soviet experimental technique, the measuring instruments are not carried in the rocket itself but in automatically jettisoned containers, the results being recorded on film and the containers recovered by parachute. The papers were entitled "Study of the Upper Atmosphere by Means of Rockets at the USSR Academy of Sciences," by S. M. Poloskov and B. A. Mirtov, and "Study of the Vital Activity of Animals during Rocket Flights into the Upper Atmosphere," by A. V. Pokrovskii, director of the USSR Institute of Experimental Aeromedicine.

The paper by Poloskov and Mirtov describes an instrument container, 2 meters long and 0.4 meter in diameter, used for upper-atmosphere research. It is essentially a metal cylinder divided into three sections. The lower section is hermetically sealed and contains power supplies, ammeters, camera, and the program mechanism which controls the operation of all the instruments in the container. The center section--which is open to the atmosphere--contains evacuated glass sampling flasks, thermal and ionization gauges, etc. The upper section contains a parachute and is also hermetically sealed. A set of spikes in the bottom of the container ensures a vertical landing. The container, which weighs about 250 kilograms, is jettisoned automatically in the descending phase of the trajectory at a height of 10 to 12 kilometers above the earth's surface.

Pokrovskii's paper describes a catapultable chassis used in studying

the behavior of dogs during round-trip flights to altitudes of 110 kilometers. The dog is secured in a hermetically sealed space suit with a removable plastic helmet and is provided with a two-hour supply of oxygen. The chassis is equipped with radio transmitter, oscillograph, thermometers, sphygmometer, camera, and parachute. Two such chassis are fitted in the rocket nose section, which separates from the body of the rocket at the apex of the trajectory. One chassis separates from the nose section at a height of 80 to 90 kilometers and parachutes to the ground from a height of 75 to 85 kilometers. The other chassis separates at a height of 45 to 50 kilometers and falls freely to a height of 3 to 4 kilometers before parachuting to the ground.

As one might expect, the subject matter of these two papers received extremely wide publicity in the Soviet press. Probably the most comprehensive review was given by Academician Blagonravov himself in an article entitled "Investigation of the Upper Layers of the Atmosphere by Means of High-Altitude Rockets," which appeared in Vestnik Akademii Nauk SSSR in June, 1957. Besides mentioning by name the key personnel in the program, Blagonravov stated that cosmic-ray investigations by means of rockets were initiated in the Soviet Union in 1947, that atmospheric composition studies to altitudes of 100 kilometers began in 1949, and that systematic studies of the atmosphere--including the use of dogs--were conducted from 1951 to 1956.

By way of interlude, a TASS dispatch dateline Moscow, June 13, 1957, reads as follows:

"A press conference was held by the State Committee for Cultural Relations [illegible]

were shown living travelers into extraterrestrial space--three dogs who were sent up in rockets to a height of 100 kilometers and more. Two of them have made two flights each and are in good health. All the flights were filmed. It was found that the animals behaved normally when flying to this height at a speed of 1170 meters per second. Alexei Pokrovskii, a member of the Soviet Committee for the International Geophysical Year, said, 'I would like the British correspondents to inform the British Society of Happy Dogs about this because the Society has protested to the Soviet Union against such experiments.'"

In June, 1957, Academician I. P. Bardin submitted by letter to CSAOI at Brussels the official USSR Rocket and Earth Satellite Program for the IGY. This program, which was merely an outline, indicated, among other things, that the Russians would fire 125 meteorological research rockets from three different geographical zones and would establish an unspecified number of artificial earth satellites.

Of the numerous statements made by various Soviet scientists in the Press and on the radio concerning the imminent launching of the first Soviet satellite those by Academician A. N. Nesmeyanov were probably the most pertinent. On June 1, 1957, Pravda quoted Nesmeyanov as follows: "As a result of many years of work by Soviet scientists and engineers to the present time, rockets and all the necessary equipment and apparatus have been created by means of which the problem of an artificial earth satellite for scientific research purposes can be solved." A week later, Nesmeyanov said that "soon, literally within the

next months, our planet earth will acquire another satellite.... The technical difficulties that stood in the way of the solution of this grandiose task have been overcome by our scientists. The apparatus by means of which this extremely bold experiment can be realized has already been created."[6]

In addition to these guarded statements by Nesmeyanov, and those of other Soviet scientists, the scientific literature contains several specific indications of the forthcoming launching of the first Soviet satellite. For example, a one-page announcement entitled "On the Observation of the Artificial Satellite," by A. A. Mikhailov, chairman of the Astronomical Council of the USSR Academy of Sciences, appeared on page one in the astronomical journals Astronomicheskii Tsirkulyar, May 18, 1957, and Astronomicheskii Zhurnal, May-June, 1957. After a brief description of what observers were to expect as the satellite passed overhead,[7] the announcement concluded with the following statements:

> "The Astronomical Council of the USSR Academy of Sciences requests all astronomical organizations, all astronomers of the Soviet Union, and all members of the All-Union Astronomical and Geodetic Society to participate actively in preparations for the visual observations of artificial satellites.

---

[6] Komsomolskaya Pravda, June 9, 1957.

[7] Readers will find a striking similarity between this description and that of the Moonwatch program of the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts, the various aspects of which are described in the observatory's Bulletin for Visual Observers of Satellites which began publication in July, 1956. This bulletin, issued at irregular intervals, may be found as a center insert in the monthly journal Sky and Telescope.

"Instructions and special apparatus for observation can be obtained through the Astronomical Council."[8]

Two articles in the June, 1957, issue of the Russian amateur-radio magazine, Radio,[9] provide further evidence of the imminent establishment of Sputnik I. The articles, entitled "Artificial Earth Satellites - Information for Radio Amateurs," by V. Vakhnin and "Observations of the Radio Signals from the Artificial Earth Satellite and Their Scientific Importance," by A. Kazantsev, gave a fairly comprehensive description not only of a satellite's orbit and how the subsequent appearances of a satellite can be predicted, but also of the satellite's radio transmitters, how the 20- and 40-megacycle frequency signals are to be used, and what information about the upper atmosphere can be derived from them.

The July and August issues of Radio carried articles on how to build a recommended short-wave-radio receiver and a direction-finding attachment for tracking the Soviet Sputniks. Moreover, to inform the Russian radio amateurs about developments in the United States, the July issue of the magazine carried an article based on material taken from the American amateur-radio magazine QST describing the Minitrack II system which would permit radio amateurs to track American satellites with comparatively inexpensive equipment. This item was followed immediately by a notice

---

[8] The telescopes used by members of Russian Moonwatch teams, as shown in photographs in Pravda and other Russian newspapers, after the launching of Sputnik I, are suspiciously similar in outward appearance to the design described in the Bulletin for Visual Observers of Satellites.

[9] Radio is an organ of the USSR Ministry of Communication and of DOSAAF (The All-Union Volunteer Society for the Promotion of the Army, Aviation and Navy) and corresponds to the American amateur-radio magazine, QST, published by the American Radio Relay League.

in boldface type to Soviet radio amateurs to make preparations for tracking the Russian scientific earth satellites and contained detailed instructions on how to submit data on the signals received and recorded to Moskva--Sputnik for reduction and analysis by the Institute of Radio Engineering and Electronics of the USSR Academy of Sciences.

That the Soviets were in earnest about their missile capabilities and space-flight intentions became indubitably clear on August 27, 1957, when a TASS report in Pravda stated that "successful tests of an intercontinental ballistic rocket and also explosions of nuclear and thermonuclear weapons have been carried out in conformity with the plan of scientific research work in the USSR."

There was considerable prognostication that the Soviets would launch a satellite on September 17, 1957, the 100th anniversary of the birth of K. E. Tsiolkovskii, the founder of the science of astronautics. Needless to say, this day was the occasion for speeches by many leading scientists, both at the Hall of Columns in Moscow and at Peace Square in Kaluga, a small town about 160 kilometers southwest of Moscow, where Tsiolkovskii had spent the greater part of his life. At Kaluga the Soviets will erect a monument depicting Tsiolkovskii in flowing cape, looking into the sky, and standing on a pedestal in front of a long slender rocket poised in a vertical takeoff position.

The climax to this chronicle occurred, of course, on October 4, 1957, when Sputnik I was established in its orbit. Appropriately enough, even on this occasion the far-sighted Soviets had scientific delegations strategically placed in foreign capitals. Washington played host to IGY delegates

A. A. Blagonravov, V. V. Belousov, A. M. Kasatkin, and S. M. Poloskov, who were, needless to say, overjoyed on hearing that the satellite had been launched successfully. In Barcelona, where the Eighth International Astronautical Congress was convening, a Soviet delegation of four, headed by L. I. Sedov, made the most of the occasion by presenting two papers, one by L. V. Kurnosova on the investigation of cosmic radiation by means of an artificial earth satellite and the other by A. T. Masevich on the preparation for visual observation of artificial satellites – a Soviet version of the Moonwatch program. Sedov also distributed a limited number of copies of the special 284-page September, 1957, issue of Uspekhi Fizicheskikh Nauk, which contains seventeen papers on various aspects of Soviet rocket and satellite research.

SOVIET LITERATURE ON SPACE FLIGHT

Russia has a well-established literature on rocketry and space flight. This literature includes not only the classic works of her own pioneers, but also translations of foreign monographs by Esnault-Pelterie, Oberth, Hohmann, Goddard, Sanger, and others. The Soviets have also "liberated" a vast amount of detailed material from German industrial firms and scientific and technological institutes. Russian textbooks on rocketry, for instance, consider details of German developments that are not even mentioned in American books on the subject.[10]

[10] See, for example, Bolgarskii and Shchukin, Rabochie protsessy v zhidkostno-reaktivnykh dvigatelyakh (Working processes in liquid-jet engines), Oborongiz, Moscow, 1959, 424 pp.

In the post-Tsiolkovskii period the names of M. K. Tikhonravov and A. A. Shternfel'd stand out prominently in spite of the Stalin shadow. Both are capable and prolific writers. For several years the names of popular-science writers B. V. Lyapunov and M. V. Vasil'ev, engineers K. A. Gil'zin and Yu. S. Khlebtsevich, and scientist K. P. Stanyukovich have been appearing with increasing frequency as the authors of articles and books on rocketry and space flight. More recently Soviet scientists have been reporting the results of their researches not only in the technical journals but also in the popular press, either in the form of interviews or as nontechnical essays. Since 1951 a monthly journal, Voprosy Raketnoi Tekhniki (Problems of Rocket Technology), has been completely devoted to translations and surveys of the foreign periodical literature. Since 1954 the Institute of Scientific Information of the USSR Academy of Sciences has been publishing a journal Referativnyi Zhurnal: Astronomiya i Geodesiya (Reference Journal: Astronomy and Geodesy) which abstracts, among other things, foreign and domestic publications in the field of astronautics. Moreover, the Soviets have, of course, their own classified literature, which in all probability is extremely interesting.

Prior to 1955 Soviet papers on space flight followed, in general, a fixed pattern. They began with an account of the historical contributions made by the early Russian astronauts; next came a discussion of the results of tests obtained by American and other foreign rocketeers, followed by a discourse on the problems involved in the launching of a satellite vehicle and on the variety and importance of the data to be obtained from an extraterrestrial laboratory; finally, they boasted about the great efforts that Soviet scientists were exerting in creating a

scientific space station and in making cosmic flights possible for peaceful purposes. It is interesting to note that (except in one or two cases) almost no mention is made of any specific Soviet developments or results. Thus, for example, the article on rockets in the Bol'shaya Sovetskaya Entsiklopediya[11] includes two tables of rocket characteristics. Table 1 lists the characteristics of some liquid-fuel rockets, including the German A-4 (V-2) and the Wasserfall, the U.S. Viking No. 9 and the Nike, the French Véronique, and the U. S. two-stage Bumper (V-2 plus Wac Corporal) rocket. But no Russian rockets. Table 2 gives the characteristics of some rocket missiles, including the German Rheinbote and a 78-millimeter fragmentation shell, and the U. S. Mighty Mouse and Sparrow missiles. Again, no Russian missiles.[12]

In recent years Soviet papers on astronautics have become more and more specialized, dealing with such topics as chemical and nuclear rocket engines, radio guidance, meteoric impacts, weightlessness, and orbit calculations, as well as with problems to be investigated during the International Geophysical Year. Their tone has been somewhat conciliatory to the West, and the jibes at the capitalist countries, ever present in the earlier papers, are conspicuously absent.

Articles on the problems of astronautics by topnotch Soviet scientists and technologists began to appear in the official, serious scientific publications of the USSR Academy of Sciences in 1954. Typical of such

---

[11] 2nd ed., Vol. 39, pp. [illegible].

[12] There is, however, a comprehensive table of Soviet missiles and their characteristics, prepared by Alfred J. Zaehringer, in The Journal of Space Flight, May, [illegible], Chapter 1.

articles are Shternfed'd's "Problems of Cosmic Flight," published in Priroda in December, 1954, which is primarily an exposition on flight trajectories from the earth to the moon, Mars, Venus, and Mercury; Academician V. G. Fesenkov's "The Problems of Astronautics," which appeared in Priroda in June, 1955, and which was written from the point of view of an astrophysicist who touches on the possibility of using atomic energy as a source of power for space travel; and 'Contemporary Problems of Cosmic Flights," by A. G. Karpenko and G. A. Skuridan, published in Vestnik Akademii Nauk SSSR, in September, 1955. The last article is a comprehensive survey of the state-of-the-art gleaned largely from papers presented at the Fifth and Sixth International Astronautical Congresses. It concludes, significantly, with the following statements:

"Together with the utilization of atomic energy for peaceful purposes and the development of the technology of semiconductors and new computing machines, the problem of interplanetary communications belongs with those problems which will open to mankind great areas of scientific cognition and the conquest of nature.

"The importance of this problem was clearly described by Academician P. L. Kapitsa, a member of the Commission on Interplanetary Communications: '. . . if in any branch of knowledge the possibilities of penetrating a new, virgin field of investigation are opening, then it must be done without fail, because the history of science teaches that, as a rule, it is precisely this penetration of new fields that leads to the discovery of those very important phenomena of nature which most significantly

widen the paths of the development of human culture...'"

The Russian technical literature of recent years gives abundant evidence of continued progress in the various disciplines associated with space flight. One of the most important pieces of evidence was the publication a few years ago of tables of thermodynamic properties, ranging from 298°K to 5000°K, of such chemical species as $F_2$, HF, CH, $CH_2$, $CH_3$, and $C_2$. The first two indicate an interest in fluorine as an oxidant in chemical-rocket propellant systems, and the latter four, an interest in hydrocarbons as possible propellants in nuclear rockets.

The subject of nuclear-powered rockets is treated by K. P. Stanyukovich in an article entitled "Problems of Interplanetary Flights," which appeared in the August 10, 1954, issue of Krasnaya Zvezda, and in a slightly more expanded form as a paper entitled "Rockets for Interplanetary Flights" in the book, Problemy Ispol'zovaniya Atomnoi Energii (Problems of Utilizing Atomic Energy), published in 1956. Diagrams of nuclear-powered turbojet, ramjet, and rocket engines illustrate G. Nesterenko's article, "The Atomic Airplane of the Future," published in Kryl'ya Rodiny in January, 1956, while R. G. Perel'man's article, "Atomic Engines," in the January, 1956, issue of Nauka i Zhizn', includes a sketch of a six-stage cosmic rocket in which the first stage is powered by a liquid-rocket engine, the second stage by a ramjet engine, the third stage by an atomic-rocket engine, and the three final stages by liquid-rocket engines.

In celebrating its 125th anniversary in 1955, the Moscow Higher Technical College, which is also known as the Bauman Institute and is the Russian counterpart of the Massachusetts Institute of Technology or

P-1457
2-24-58
AD

California Institute of Technology, published a collection of nineteen papers on theoretical mechanics, several of which had direct applications to space flight. One that is particularly relevant was written by V. F. Krotov and is entitled "Calculation of the Optimum Trajectory for the Transition of a Rocket to a Given Circular Trajectory around the Earth."

Rocket guidance has been discussed by a number of Russian experts, notably by I. Kucherov in an article entitled "Radio-guided Rockets," published in Radio in August, 1955, and by Yu. S. Khlebtsevich, who wrote several articles on rocket flights to the moon, Mars, and Venus.

Some highly interesting and original ideas have appeared in recent articles in Russian popular scientific literature. One article proposes worldwide television broadcasting by means of three earth satellites symmetrically spaced in an equatorial orbit at an altitude of 35,800 kilometers. Needless to say, the author discretely avoids mentioning the military significance of such a system. Another article suggests the use of earth satellites for the experimental verification of the general theory of relativity. This article, written by V. L. Ginzburg, is a very lucid piece of nontechnical scientific writing on a subject that is generally considered too abstruse for the layman to understand. The study of the biological problems of interplanetary flight continues to be the subject of considerable discussion and investigation.

The two general subjects that have received the most attention insofar as the Soviet press is concerned are the artificial earth satellite and

rocket flight to the moon. Prior to Sputnik I's establishment in orbit, the following scientists wrote papers on the problems associated with artificial earth satellites: K. P. Stanyukovich, "Artificial Earth Satellite," Krasnaya Zvezda, August 7, 1955; A. G. Karpenko, "Cosmic Laboratory," Moskovskaya Pravda, August 14, 1955; G. I. Pokrovskii, "Artificial Earth Satellite," Izvestiya, August 19, 1955; L. I. Sedov, "On Flights into Space," Pravda, September 26, 1955; and A. N. Nesmeyanov, "The Problem of Creating an Artificial Earth Satellite," Pravda, June 1, 1957. The first four articles were prompted largely by the White House announcement of July 29, 1955, while Nesmeyanov's article was a harbinger of Sputnik I.

In the Soviet literature there are repeated references to moon-rocket projects. For example, in an article entitled "Flight to the Moon," published in Pionerskaya Pravda on October 2, 1951, M. K. Tikhonravov, Corresponding Member of the Academy of Artillery Sciences, stated that according to engineering calculations two men could fly around the moon and back to earth in a rocket ship weighing approximately 1000 tons. Such a ship must have a velocity of about 11.1 kilometers per second. If an artificial earth satellite were available, then it would be possible to send a much smaller space ship – one weighing not more than 100 tons and having a velocity of 3.5 kilometers per second – from the satellite to the moon.

According to a German Press Agency report, the Soviet newspaper Krasnii Flot (Red Fleet) for October 12, 1951, asserted that a moon rocket had already been designed in the Soviet Union. It was said to be 60 meters long, to have a maximum diameter of 15 meters, a weight of 1000 tons,

and 20 motors with a total power of 350 million horsepower. Heinz H. Kolle of Stuttgart's Gesellschaft für Weltraumforschung evaluated these data in an article entitled "Wird in der Sowjet-Union eine Mondrakete gebaut?" in Weltraumfahrt, January, 1952. He concluded that in the optimum case a manned rocket for at best a two-man crew and a single circumnavigation of the moon with subsequent return to the earth still lies too close to the outermost limit of present attainments.

> "Even the unmanned moon messenger would require immense technical effort. The practical result would be trifling in comparison. On the other hand, the undertaking could be used psychologically and propaganda-wise, since successful execution and the corresponding accompanying fanfare would obviously demonstrate that Soviet long-range rockets would just as well reach any point on the earth's surface."

Professor K. P. Stanyukovich, a man of many interests and of prolific pen, has made several contributions in this field. His article "Trip to the Moon: Fantasy and Reality" in the English-language propaganda journal News: A Soviet Review of World Events, for June 1, 1954, is more polemic than scientific. His article "Rendezvous with Mars" in the same journal for October 16, 1956, is not quite so belligerent toward the United States. In this later article he predicts flights to the moon in five to ten years and to Mars within fifteen years, the latter being accomplished not with chemical fuels but with nuclear fuels.

Perhaps the most widely publicized moon-rocket project in the Soviet Union is that proposed by Yu. S. Khlebtsevich, which made its first appearance in an article entitled "On the Way to the Stars" in Tekhnika-Molodezhi in July, 1954; later it was published in an expanded

form as "The Road into the Cosmos" in the November, 1955, issue of Nauka i Zhizn'. Khlebtsevich suggests landing a mobile "tankette-laboratory" on the Moon. The tankette, which would weigh not more than a few hundred kilograms and would be radio controlled from the earth, would explore the surface of the moon and report its findings back to earth.[12] Information so obtained would make possible the next stage--the mastery of the moon by man in the next five to ten years.

In February, 1957, the Soviet press gave considerable publicity to a spage-flight project headed by Professor O. A. Chebotarev at the Institute of Theoretical Astronomy in Leningrad. According to Chebotarev's calculations it is possible, with the expenditure of only 16 tons of propellant, to launch a rocket vehicle weighing 50 to 100 kilograms with an initial velocity of 11 kilometers per second in an elliptical orbit around the moon. Flying solely under gravitational forces the vehicle would round the moon at a distance of 30,000 kilometers and return to the earth in 236 hours, after covering a total path length of about one million kilometers.

One of the most startling disclosures in connection with Soviet space-flight activities is the paper entitled "Some Questions on the Dynamics of Flight to the Moon" by V. A. Egorov of the Steklov Mathematics Institute in Moscow. This paper is a summary of a systematic investigation undertaken from 1953 to 1955 to find satisfactory

---

[12] This project has been made the subject of a Russian popular-science short film--of the Walt Disney type, but much inferior--and is No. 15 in a series generally entitled "Science and Technology." Since the advent of Sputnik I, the film has been shown in movie theaters throughout the United States.

solutions for the fundamental problems in the theory of flight to the moon: specifically, the problem of the form and classification of unpowered trajectories, of the possibility of periodic circumflight of the moon and the earth, and of hitting the moon. The paper also deals with the particularly important question of the effect of the dispersion of initial data on the realization of hitting or circumflight. More than 600 trajectories were calculated by means of electronic computers and were classified as hits, circumflights, or afflights (that is, approach trajectories which do not encompass the moon but allow one to see everything on its opposite side and to return to earth). This investigation is quite similar to studies of the general trajectories of a body in the earth-moon system that are being conducted in this country. The over-all results of the studies are in substantial agreement. Specific numerical comparisons can now be made, since the complete report is available.

WHAT THE SPUTNIKS MEAN

Two facts are obvious from the successful launchings of Sputniks I and II: First, there is no doubt that Russia has won a tremendous propaganda victory. Second, Russia unquestionably possesses rocket systems of proven operational reliability.

Since the Russians did not indicate beforehand what orbital elements they were striving to obtain for their scientific satellites, it is impossible to determine the guidance accuracy of their rocket systems. Suffice it to say that the Russians have propulsion and guidance capabilities of placing half-ton packages in orbit.

Nor have the Russians indicated the characteristics of the individual

rockets in the systems used to launch the satellites. It would not be difficult, however, to construct rocket systems capable of placing Sputnik I and II payloads in orbit on the basis of known information, that is, by using first- and second-stage booster rockets having 120- and 135-metric-ton-thrust engines, respectively, and a third-stage rocket of the Wasserfall type which the Russians are known to have had under development.

That the Soviets might have been prodigal with their propulsive power in launching the Sputniks seems to follow from a statement made by Yu. A. Pobedonostsev in Soviet Weekly for October 10, 1957, in describing the launching of Sputnik I: "When the first stage engines stop, after one or two minutes, the whole first stage of the rocket falls away, and the second stage engines start, bringing the now smaller rocket up to a speed of between 11,000 and 12,500 miles per hour. From then on the rocket travels by inertia, and as it rises higher so its course flattens until it is flying parallel with the earth below. By that time, the rocket is more than 6000 miles away from where it started. It is at this point that the third stage engine cuts in, and brings the satellite's speed up to its final figure of well over 17,000 miles per hour."

It is obvious that the Soviets, in their struggle for world domination, are applying their sledge-hammer technique not only to terrestrial affairs but also to the conquest of cosmic space. Heretofore, trying to follow the maneuvers of the Soviet scientific bear was like trying to decide the outcome of Frank Stockton's classic short story "The Lady or the Tiger?" Not any more!